

CLAIMS

What is claimed is:

1. A non-linear optical loop mirror for processing optical signals, comprising:
 - 5 an optical fiber with a signal input and a signal output, at least a portion of the optical fiber being a dispersion compensating fiber and at least a portion of the optical fiber forming a loop, the dispersion compensating fiber having an absolute magnitude of dispersion of at least 20 ps/nm-km for at least a portion of wavelengths in the optical signals;
 - 10 a bi-directional amplifier coupled to the optical fiber; and
 - a coupler coupled to a first portion of the optical fiber and a second portion of the optical fiber to form a fiber loop.
2. The mirror of claim 1, wherein the coupler splits a power of the optical signals with a first portion of the optical signals traveling in a first direction in the fiber loop and a second portion of optical signals traveling in a counter-propagating direction in the fiber loop.
3. The mirror of claim 1, wherein at least a portion of the dispersion compensating fiber has an absolute magnitude of dispersion of at least 20 ps/nm-km for a majority of wavelengths in the optical signals.
- 20 4. The mirror of claim 1, wherein at least a portion of the dispersion compensating fiber has an absolute magnitude of dispersion of at least 50 ps/nm-km for at least a portion of wavelengths in the optical signals.
5. The mirror of claim 1, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $2 \text{ W}^{-1}\text{km}^{-1}$.
- 25 6. The mirror of claim 1, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $3 \text{ W}^{-1}\text{km}^{-1}$.

7. The mirror of claim 2, wherein the coupler provides substantially equal coupling in the two directions.

8. The mirror of claim 2, further comprising:

5 a polarization controller coupled to the fiber loop that aligns polarizations of the optical signals of the two directions when the optical signals recombine in the fiber loop.

9. The mirror of claim 1, further comprising:

a lossy element coupled to the fiber loop.

10 10. The mirror of claim 9, wherein the lossy member is selected from an add/drop multiplexer, a gain equalizer and a dispersion compensating element.

11. The mirror of claim 1, wherein the fiber loop has a first end and a second end and the bi-directional amplifier is positioned closer to one of the first and second ends.

15 12. The mirror of claim 1, wherein the bi-directional amplifier is a rare earth doped amplifier.

13. The mirror of claim 1, wherein the bi-directional amplifier is an erbium-doped fiber amplifier.

20 14. The mirror of claim 1, wherein the bi-directional amplifier is a Raman amplifier.

15. The mirror of claim 1, wherein the dispersion compensating fiber has a sufficiently large dispersion to minimize phase shift interactions between adjacent wavelength signals of the optical signals.

25 16. The mirror of claim 15, wherein the phase shift from cross phase modulation between adjacent wavelengths in the optical signals is no more

than $\frac{1}{4}$ of a phase shift from self phase modulation of one of the adjacent wavelengths.

17. The mirror of claim 1, wherein the fiber loop includes at least eight walk-off lengths.

5 18. The mirror of claim 1, wherein the mirror provides simultaneous amplification and dispersion compensation of an optical signal.

19. The mirror of claim 1, wherein the mirror provides simultaneous amplification, dispersion compensation and boosting of signal to noise ratio of an optical signal.

10 20. The mirror of claim 1, wherein the mirror provides simultaneous amplification, dispersion compensation and boosting of signal to noise ratio of an optical signal.

21. A non-linear optical loop mirror for processing optical signals, comprising:

15 a first optical fiber with a signal input and a signal output,
a second optical fiber coupled to the first optical fiber to form a fiber loop, at least a portion of the second optical fiber being a dispersion compensating fiber that has an absolute magnitude of dispersion of at least 20 ps/nm-km for at least a portion of wavelengths in the optical signals; a bi-
20 directional amplifier coupled to at least one of the first and second optical fibers; and
a coupler coupled to the first and second optical fiber.

22. The mirror of claim 21, wherein the coupler splits a power of an optical signal with a first portion traveling in a first direction in the fiber loop
25 and a second portion traveling in a counter-propagating direction in the fiber loop.

23. The mirror of claim 21, wherein at least a portion of the dispersion compensating fiber has an absolute magnitude of dispersion of at least 20 ps/nm-km for a majority of wavelengths in the signal.

24. The mirror of claim 21, wherein at least a portion of the dispersion compensating fiber has an absolute magnitude of dispersion of at least 50 ps/nm-km for at least a portion of wavelengths in the signal.

25. The mirror of claim 21, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $2 \text{ W}^{-1}\text{km}^{-1}$.

26. The mirror of claim 21, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $3 \text{ W}^{-1}\text{km}^{-1}$.

27. The mirror of claim 22, wherein the coupler provides substantially equal coupling in the two directions.

28. The mirror of claim 22, further comprising:
a polarization controller coupled to the fiber loop that aligns polarizations of the optical signals of the two directions when the optical signals recombine in the fiber loop.

29. The mirror of claim 21, further comprising:
a lossy element coupled to the fiber loop.

30. The mirror of claim 29, wherein the lossy member is selected from an add/drop multiplexer, a gain equalizer and a dispersion compensating element.

31. The mirror of claim 21, wherein the fiber loop has a first end and a second end, wherein the bi-directional amplifier is positioned closer to one of the first and second ends.

32. The mirror of claim 21, wherein the bi-directional amplifier is a rare earth doped amplifier.

33. The mirror of claim 21, wherein the bi-directional amplifier is an erbium-doped fiber amplifier

5 34. The mirror of claim 21, wherein the bi-directional amplifier is a Raman amplifier.

35. The mirror of claim 21, wherein the dispersion compensating fiber has a sufficiently large dispersion to minimize phase shift interactions between adjacent wavelength signals of the optical signals.

10 36. The mirror of claim 35, wherein the phase shift from cross phase modulation between adjacent wavelengths in the optical signals is no more than $\frac{1}{4}$ of a phase shift from self phase modulation of one of the adjacent wavelengths.

15 37. The mirror of claim 21, wherein the fiber loop includes at least eight walk-off lengths.

38. The mirror of claim 21, wherein the mirror provides simultaneous amplification and dispersion compensation of an optical signal.

20 39. The mirror of claim 21, wherein the mirror provides simultaneous amplification, dispersion compensation and boosting of signal to noise ratio of an optical signal.

40. The mirror of claim 21, wherein the bi-directional amplifier provides a gain to the optical signals of at least 10 dB.

25 41. A method of processing optical signals, comprising:
providing a non-linear optical loop mirror that includes a dispersion compensating fiber and a fiber loop, the dispersion compensating fiber

having an absolute magnitude of dispersion of at least 20 ps/nm-km for at least a portion of wavelengths in the optical signals;

introducing the optical signal to the non-linear optical loop mirror;

5 simultaneously amplifying and dispersion compensating the optical signal in the non-linear optical loop mirror.

42. The method of claim 41, further comprising:

simultaneously amplifying, dispersion compensating and boosting the signal to noise ratio of the optical signal in the non-linear optical loop mirror.

43. The method of claim 41, further comprising:

10 splitting a power of an optical signal in the non-linear optical mirror with a first portion traveling in a first direction in the fiber loop and a second portion traveling in a counter-propagating direction in the fiber loop.

44. The method of claim 41, wherein at least a majority of the dispersion compensating fiber has an absolute magnitude of dispersion of at least 20
15 ps/nm-km for at least a portion of wavelengths in the signal.

45. The method of claim 41, further comprising:

wherein at least a portion of the dispersion compensating fiber has an absolute magnitude of dispersion of at least 50 ps/nm-km for at least a portion of wavelengths in the optical signal.

20 46. The method of claim 43, further comprising:

providing substantially equal coupling of the first and second portion in the two directions.

47. The method of claim 43, further comprising:

aligning polarizations of the optical signal of the two directions
25 when recombined in the fiber loop.

48. The method of claim 41, further comprising:

wherein the dispersion compensating fiber has a sufficiently large dispersion to minimize phase shift interactions between adjacent wavelength signals of the optical signals.

49. The method of claim 48, wherein the phase shift from cross
5 phase modulation between adjacent wavelengths in the optical signals is no more than $\frac{1}{4}$ of a phase shift from self phase modulation of one of the adjacent wavelengths.

50. The method of claim 41, wherein the fiber loop includes at least eight walk-off lengths.

10 51. The method of claim 41, further comprising:
providing gain to the optical signal of at least 10 dB.

52. A non-linear optical loop mirror for processing optical signals,
comprising:

15 an optical fiber with a signal input, a signal output and a fiber loop, at least a portion of the optical fiber having a sufficiently large dispersion to minimize phase shift interactions between adjacent wavelength signals of the optical signals, at least a portion of the optical fiber forming a fiber loop;
a bi-directional amplifier coupled to the optical fiber; and
a coupler coupled to the fiber loop.

20 53. The mirror of claim 52, wherein the phase shift from cross phase modulation between adjacent wavelengths in the optical signals is no more than $\frac{1}{4}$ of a phase shift from self phase modulation of one of the adjacent wavelengths.

25 54. An optical regeneration system, comprising:
a wavelength demultiplexer;
a wavelength multiplexer;
a plurality of nonlinear optical loop mirrors, each comprising:

a first fiber comprising a first end, a second end, and a first effective nonlinearity determined at least by an index of refraction of the first fiber and an effective area of the first fiber;

a second fiber comprising a first end, a second end, and a second effective nonlinearity determined at least by an index of refraction of the second fiber and an effective area of the second fiber, wherein the first effective nonlinearity is distinct from the second effective nonlinearity, and at least a portion of one or both of the first fiber and the second fiber form a fiber loop; and

a coupler coupled to the first end of the first fiber, the first end of the second fiber, the wavelength demultiplexer, and the wavelength multiplexer; and

a first bidirectional amplifier coupled to the second end of the first fiber and the second end of the second fiber, and amplifying at least signals traveling in a first direction from the second end of the first fiber to the second end of the second fiber and signals traveling in a second direction from the second end of the second fiber to the second end of the first fiber.

55. The mirror of claim 54, wherein the coupler splits a power of an optical signal with a first portion traveling in a first direction in the fiber loop and a second portion traveling in a counter-propagating direction in the fiber loop.

56. The mirror of claim 54, wherein at least a portion of the optical fiber with an absolute magnitude of dispersion of at least 20 ps/nm-km for at least a portion of wavelengths in the signal.

57. The mirror of claim 54, wherein at least a portion of optical fiber has an absolute magnitude of dispersion of at least 50 ps/nm-km for at least a portion of wavelengths in the signal.

58. The mirror of claim 54, wherein the optical fiber has a nonlinear coefficient greater than $2 \text{ W}^{-1}\text{km}^{-1}$.

59. The mirror of claim 54, wherein the optical fiber has a nonlinear coefficient greater than $3 \text{ W}^{-1}\text{km}^{-1}$.

5 60. The mirror of claim 54, wherein the coupler splits a power of the optical signals with a first portion of the optical signals traveling in a first direction in the fiber loop and a second portion of optical signals traveling in a counter-propagating direction in the fiber loop.

10 61. The mirror of claim 60, wherein the coupler provides substantially equal coupling in the two directions.

62. The mirror of claim 60, further comprising:
a polarization controller coupled to the fiber loop that aligns polarizations of the optical signals of the two directions when the optical signals recombine in the fiber loop..

15 63. The mirror of claim 52, further comprising:
a lossy element coupled to the fiber loop..

64. The mirror of claim 63, wherein the lossy member is selected from an add/drop multiplexer, a gain equalizer and a dispersion compensating element.

20 65. The mirror of claim 52, wherein the fiber loop has a first end and a second end, wherein the bi-directional amplifier is positioned closer to one of the first and second ends.

66. The mirror of claim 52, wherein the bi-directional amplifier is a rare earth doped amplifier.

67. The mirror of claim 52, wherein the bi-directional amplifier is an erbium-doped fiber amplifier.

68. The mirror of claim 52, wherein the bi-directional amplifier is a Raman amplifier.

5 69. The mirror of claim 52, wherein the fiber loop includes at least eight walk-off lengths.

70. The mirror of claim 52, wherein the mirror provides simultaneous amplification and dispersion compensation of an optical signal.

10 71. The mirror of claim 52, wherein the mirror provides simultaneous amplification, dispersion compensation and boosting of signal to noise ratio of an optical signal.

72. The mirror of claim 52, wherein the mirror provides a bi-directional amplifier gain of at least 10 dB.

15 73. An optical system for processing optical signals, comprising:
an input optical fiber;
a splitter coupled to the input optical fiber and separates adjacent channels of an input optical signal; and

at least a first loop mirror coupled to the splitter, the at least first loop mirror including a fiber loop, at least a portion of the fiber loop including a
20 dispersion compensating fiber, at least a portion of the dispersion compensating fiber having an absolute magnitude of dispersion of 20 ps/nm-km for a majority of wavelengths in the optical signals.

25 74. The system of claim 73, further comprising:
a combiner coupled to the at least first loop mirror; and
at least one output fiber coupled to the combiner.

75. The system of claim 73, further comprising:

a coupler that splits a power of the optical signals with a first portion of the optical signals traveling in a first direction in the fiber loop and a second portion of optical signals traveling in a counter-propagating direction in the fiber loop.

5 76. The system of claim 73, wherein at least a portion of the dispersion compensating fiber has an absolute magnitude of dispersion of at least 50 ps/nm-km for at least a portion of wavelengths in the optical signals.

77. The system of claim 73, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $2 \text{ W}^{-1}\text{km}^{-1}$.

10 78. The system of claim 73, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $3 \text{ W}^{-1}\text{km}^{-1}$.

79. The system of claim 75, wherein the coupler provides substantially equal coupling in the two directions.

15 80. The system of claim 75, further comprising:
a polarization controller coupled to the fiber loop that aligns polarizations of the optical signals of the two directions when the optical signals recombine in the fiber loop.

81. The system of claim 73, further comprising:
a lossy element coupled to the fiber loop.

20 82. The system of claim 81, wherein the lossy member is selected from an add/drop multiplexer, a gain equalizer and a dispersion compensating element.

83. The system of claim 73, further comprising:
a bi-directional amplifier positioned closer to one of a first end and a
25 second end of the fiber loop.

84. The system of claim 83, wherein the bi-directional amplifier is a rare earth doped amplifier.

85. The system of claim 83, wherein the bi-directional amplifier is an erbium- doped fiber amplifier.

5 86. The system of claim 83, wherein the bi-directional amplifier is a Raman amplifier.

87. The system of claim 73, wherein the dispersion compensating fiber has a sufficiently large dispersion to minimize phase shift interactions between adjacent wavelength signals of the optical signals.

10 88. The system of claim 87, wherein the phase shift from cross phase modulation between adjacent wavelengths in the optical signals is no more than $\frac{1}{4}$ of a phase shift from self phase modulation of one of the adjacent wavelengths.

15 89. The system of claim 73, wherein the fiber loop includes at least eight walk-off lengths.

90. The system of claim 73, wherein the mirror provides simultaneous amplification and dispersion compensation of an optical signal.

20 91. The system of claim 73, wherein the mirror provides simultaneous amplification, dispersion compensation and boosting of signal to noise ratio of an optical signal.

92. The system of claim 83, wherein the bi-directional amplifier provides a gain to the optical signals of at least 10 dB.

93. A non-linear optical loop mirror, comprising:
a first optical fiber with a first effective non-linearity;

a second optical fiber coupled to the first optical fiber and forming a fiber loop, the second optical fiber having a second effective non-linearity that is different from the first effective non-linearity;

a coupler coupled to the first and second optical fibers, and

5 wherein a length of the first optical fiber is greater than a walk-off length for at least a portion of adjacent wavelengths propagating in the first fiber.

94. The mirror of claim 93, wherein a length of the second fiber is greater than a walk-off length for at least a portion of adjacent wavelengths propagating in the second fiber.

95. The mirror of claim 93, wherein the first effective non-linearity is directly proportional to a non-linear index of refraction of the first optical fiber and inversely proportion to an effective area of the first optical fiber, and the second effective non-linearity is directly proportional to a non-linear index of refraction of the second optical fiber and inversely proportion to an effective area of the second optical fiber.

96. The mirror of claim 93, wherein a difference between the first and second effective non-linearities is greater than 20% of at least one of the first and second effective non-linearities.

97. The mirror of claim 93, wherein the first and second optical fibers have different dispersions.

98. The mirror of claim 93, wherein the coupler splits a power of an optical signal with a first portion traveling in a first direction in the fiber loop and a second portion traveling in a counter-propagating direction in the fiber loop.

99. The mirror of claim 93, wherein at least a portion of one of the first and second optical fibers is a dispersion compensating fiber that has an

absolute magnitude of dispersion of at least 20 ps/nm-km for at least a portion of wavelengths in the signal.

100. The mirror of claim 93, wherein at least a portion of one of the first and second optical fibers is a dispersion compensating fiber that has an absolute magnitude of dispersion of at least 50 ps/nm-km for at least a portion of wavelengths in the signal.

101. The mirror of claim 99, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $2 \text{ W}^{-1}\text{km}^{-1}$.

102. The mirror of claim 99, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $3 \text{ W}^{-1}\text{km}^{-1}$.

103. The mirror of claim 98, wherein the coupler provides substantially equal coupling in the two directions.

104. The mirror of claim 98, further comprising:
a polarization controller coupled to the fiber loop that aligns polarizations of the optical signals of the two directions when the optical signals recombine in the fiber loop.

105. The mirror of claim 93, further comprising:
a lossy element coupled to the fiber loop.

106. The mirror of claim 105, wherein the lossy member is selected from an add/drop multiplexer, a gain equalizer and a dispersion compensating element.

107. The mirror of claim 93, wherein at least one of the first and second optical fibers has a sufficiently large dispersion to minimize phase shift interactions between adjacent wavelength signals of the optical signals.

108. The mirror of claim 107, wherein the phase shift from cross phase modulation between adjacent wavelengths in the optical signals is no more than $\frac{1}{4}$ of a phase shift from self phase modulation of one of the adjacent wavelengths.

5 109. The mirror of claim 93, wherein the mirror provides simultaneous dispersion compensation and boosting of signal to noise ratio of an optical signal.

110. The mirror of claim 93, wherein at least one of the first and second optical fibers has a length of at least 100 m.

10 111. A non-linear optical loop mirror, comprising:
a first optical fiber with a first effective non-linearity;
a second optical fiber coupled to the first optical fiber and forming a fiber loop, the second optical fiber having a second effective non-linearity that is different from the first effective non-linearity;
15 a bi-directional amplifier coupled to at least one of the first and second optical fibers; and
a coupler coupled to the first and second optical fibers.

20 112. The mirror of claim 111, wherein a length of the first optical fiber is greater than a walk-off length for at least a portion of adjacent wavelengths propagating in the first fiber.

113. The mirror of claim 111, wherein a length of the second fiber is greater than a walk-off length for at least a portion of adjacent wavelengths propagating in the second fiber.

25 114. The mirror of claim 111, wherein the first effective non-linearity is directly proportional to a non-linear index of refraction of the first optical fiber and inversely proportion to an effective area of the first optical fiber, and the second effective non-linearity is directly proportional to a non-linear index

of refraction of the second optical fiber and inversely proportion to an effective area of the second optical fiber.

115. The mirror of claim 111, wherein a difference between the first and second effective non-linearities is greater than 20% of at least one of the first and second effective non-linearities.

116. The mirror of claim 111, wherein the first and second optical fibers have different dispersions.

117. The mirror of claim 111, wherein the coupler splits a power of an optical signal with a first portion traveling in a first direction in the fiber loop and a second portion traveling in a counter-propagating direction in the fiber loop.

118. The mirror of claim 111, wherein at least a portion of one of the first and second optical fibers is a dispersion compensating fiber that has an absolute magnitude of dispersion of at least 20 ps/nm-km for at least a portion of wavelengths in the signal.

119. The mirror of claim 111, wherein at least a portion of one of the first and second optical fibers is a dispersion compensating fiber that has an absolute magnitude of dispersion of at least 50 ps/nm-km for at least a portion of wavelengths in the signal.

120. The mirror of claim 111, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $2 \text{ W}^{-1}\text{km}^{-1}$.

121. The mirror of claim 118, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $3 \text{ W}^{-1}\text{km}^{-1}$.

122. The mirror of claim 117, wherein the coupler provides substantially equal coupling in the two directions.

123. The mirror of claim 117, further comprising:
a polarization controller coupled to the fiber loop that aligns
polarizations of the optical signals of the two directions when the optical
signals recombine in the fiber loop.

5 124. The mirror of claim 111, further comprising:
a lossy element coupled to the fiber loop.

125. The mirror of claim 124, wherein the lossy member is selected from
an add/drop multiplexer, a gain equalizer and a dispersion compensating
element.

10 126. The mirror of claim 111, wherein the bi-directional amplifier is
coupled to each of the first and second optical fibers.

127. The mirror of claim 111, wherein the bi-directional amplifier is
positioned substantially at a midpoint of the fiber loop.

128. The mirror of claim 111, wherein the bi-directional amplifier is a rare
5 earth doped amplifier.

129. The mirror of claim 111, wherein the bi-directional amplifier is an
erbium- doped fiber amplifier.

130. The mirror of claim 111, wherein the bi-directional amplifier is a
Raman amplifier.

20 131. The mirror of claim 111, wherein at least one of the first and second
optical fibers has a sufficiently large dispersion to minimize phase shift
interactions between adjacent wavelength signals of the optical signals.

132. The mirror of claim 131, wherein the phase shift from cross phase
modulation between adjacent wavelengths in the optical signals is no more

than $\frac{1}{4}$ of a phase shift from self phase modulation of one of the adjacent wavelengths.

133. The mirror of claim 111, wherein the mirror provides simultaneous amplification and dispersion compensation of an optical signal.

5 134. The mirror of claim 111, wherein the mirror provides simultaneous amplification, dispersion compensation and boosting of signal to noise ratio of an optical signal.

135. The mirror of claim 111, wherein the bi-directional amplifier provides a gain to the optical signals of at least 10 dB.

10 136. The mirror of claim 111 wherein at least one of the first and second optical fibers has a length of at least 100 m.

137. An optical system for processing optical signals, comprising:
an input optical fiber;
a splitter coupled to the input optical fiber and separates adjacent
15 channels of an input optical signal; and
at least a first loop mirror coupled to the splitter, the at least first loop mirror including:
an optical fiber with a signal input and a signal output, at least a
portion of the optical fiber being a dispersion compensating fiber and at least
20 a portion of the optical fiber forming a loop, the dispersion compensating fiber having an absolute magnitude of dispersion of at least 20 ps/nm-km for at least a portion of wavelengths in the optical signals;
a bi-directional amplifier coupled to the optical fiber; and
a coupler coupled to a first portion of the optical fiber and a second
25 portion of the optical fiber to form a fiber loop.

138. The mirror of claim 137, wherein the coupler splits a power of the optical signals with a first portion of the optical signals traveling in a first

direction in the fiber loop and a second portion of optical signals traveling in a counter-propagating direction in the fiber loop.

139. The mirror of claim 137, wherein at least a portion of the dispersion compensating fiber has an absolute magnitude of dispersion of at least 20
5 ps/nm-km for a majority of wavelengths in the optical signals.

140. The mirror of claim 137, wherein at least a portion of the dispersion compensating fiber has an absolute magnitude of dispersion of at least 50 ps/nm-km for at least a portion of wavelengths in the optical signals.

141. The mirror of claim 137, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $2 \text{ W}^{-1}\text{km}^{-1}$.
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142. The mirror of claim 137, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $3 \text{ W}^{-1}\text{km}^{-1}$.

143. The mirror of claim 138, wherein the coupler provides substantially equal coupling in the two directions.

144. The mirror of claim 138, further comprising:
a polarization controller coupled to the fiber loop that aligns
polarizations of the optical signals of the two directions when the optical
signals recombine in the fiber loop.
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145. The mirror of claim 137, further comprising:
a lossy element coupled to the fiber loop.
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146. The mirror of claim 145, wherein the lossy member is selected from an add/drop multiplexer, a gain equalizer and a dispersion compensating element.

147. The mirror of claim 137, wherein the fiber loop has a first end and a second end and the bi-directional amplifier is positioned closer to one of the first and second ends.

148. The mirror of claim 137, wherein the bi-directional amplifier is a rare
5 earth doped amplifier.

149. The mirror of claim 137, wherein the bi-directional amplifier is an erbium- doped fiber amplifier.

150. The mirror of claim 137, wherein the bi-directional amplifier is a Raman amplifier.

10 151. The mirror of claim 137, wherein the dispersion compensating fiber has a sufficiently large dispersion to minimize phase shift interactions between adjacent wavelength signals of the optical signals.

15 152. The mirror of claim 151, wherein the phase shift from cross phase modulation between adjacent wavelengths in the optical signals is no more than $\frac{1}{4}$ of a phase shift from self phase modulation of one of the adjacent wavelengths.

153. The mirror of claim 137, wherein the fiber loop includes at least eight walk-off lengths.

20 154. The mirror of claim 137, wherein the mirror provides simultaneous amplification and dispersion compensation of an optical signal.

155. The mirror of claim 137, wherein the mirror provides simultaneous amplification, dispersion compensation and boosting of signal to noise ratio of an optical signal.

25 156. The mirror of claim 137, wherein the mirror provides simultaneous amplification, dispersion compensation and boosting of signal to noise ratio of an optical signal.

157. The mirror of claim 137, further comprising:
a combiner coupled to the at least first loop mirror; and
at least one output fiber coupled to the combiner.

5 158. An optical system for processing optical signals, comprising:
an input optical fiber;
a splitter coupled to the input optical fiber and separates
adjacent channels of an input optical signal; and
at least a first loop mirror coupled to the splitter, the at least
first loop mirror including:
10 a first optical fiber with a signal input and a signal output,
a second optical fiber coupled to the first optical fiber to form a fiber
loop, at least a portion of the second optical fiber being a dispersion
compensating fiber that has an absolute magnitude of dispersion of at least
20 ps/nm-km for at least a portion of wavelengths in the optical signals;
15 a bi-directional amplifier coupled to at least one of the first and
second optical fibers; and
a coupler coupled to the first and second optical fiber.

20 159. The mirror of claim 158, wherein the coupler splits a power of an
optical signal with a first portion traveling in a first direction in the fiber loop
and a second portion traveling in a counter-propagating direction in the fiber
loop.

160. The mirror of claim 158, wherein at least a portion of the dispersion
compensating fiber has an absolute magnitude of dispersion of at least 20
ps/nm-km for a majority of wavelengths in the signal.

25 161. The mirror of claim 158, wherein at least a portion of the dispersion
compensating fiber has an absolute magnitude of dispersion of at least 50
ps/nm-km for at least a portion of wavelengths in the signal.

162. The mirror of claim 158, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $2 \text{ W}^{-1}\text{km}^{-1}$.

163. The mirror of claim 158, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $3 \text{ W}^{-1}\text{km}^{-1}$.

5 164. The mirror of claim 159, wherein the coupler provides substantially equal coupling in the two directions.

165. The mirror of claim 159, further comprising:
a polarization controller coupled to the fiber loop that aligns
10 polarizations of the optical signals of the two directions when the optical signals recombine in the fiber loop.

166. The mirror of claim 158, further comprising:
a lossy element coupled to the fiber loop.

167. The mirror of claim 166, wherein the lossy member is selected
from an add/drop multiplexer, a gain equalizer and a dispersion
15 compensating element.

168. The mirror of claim 158, wherein the fiber loop has a first end and a second end, wherein the bi-directional amplifier is positioned closer to one of the first and second ends.

169. The mirror of claim 158, wherein the bi-directional amplifier is a
20 rare earth doped amplifier.

170. The mirror of claim 158, wherein the bi-directional amplifier is an erbium-doped fiber amplifier

171. The mirror of claim 158, wherein the bi-directional amplifier is a Raman amplifier.

172. The mirror of claim 158, wherein the dispersion compensating fiber has a sufficiently large dispersion to minimize phase shift interactions between adjacent wavelength signals of the optical signals.

173. The mirror of claim 172, wherein the phase shift from cross phase modulation between adjacent wavelengths in the optical signals is no more than $\frac{1}{4}$ of a phase shift from self phase modulation of one of the adjacent wavelengths.

174. The mirror of claim 158, wherein the fiber loop includes at least eight walk-off lengths.

175. The mirror of claim 158, wherein the mirror provides simultaneous amplification and dispersion compensation of an optical signal.

176. The mirror of claim 158, wherein the mirror provides simultaneous amplification, dispersion compensation and boosting of signal to noise ratio of an optical signal.

177. The mirror of claim 158, wherein the bi-directional amplifier provides a gain to the optical signals of at least 10 dB.

178. The mirror of claim 158, further comprising:
a combiner coupled to the at least first loop mirror; and
at least one output fiber coupled to the combiner.

179. An optical system for processing optical signals, comprising:
an input optical fiber;
a splitter coupled to the input optical fiber and separates adjacent channels of an input optical signal; and
at least a first loop mirror coupled to the splitter, the at least first loop mirror including:
a first optical fiber with a first effective non-linearity;

a second optical fiber coupled to the first optical fiber and forming a fiber loop, the second optical fiber having a second effective non-linearity that is different from the first effective non-linearity;

a coupler coupled to the first and second optical fibers, and

5 wherein a length of the first optical fiber is greater than a walk-off length for at least a portion of adjacent wavelengths propagating in the first fiber.

10 180. The mirror of claim 179, wherein a length of the second fiber is greater than a walk-off length for at least a portion of adjacent wavelengths propagating in the second fiber.

15 181. The mirror of claim 179, wherein the first effective non-linearity is directly proportional to a non-linear index of refraction of the first optical fiber and inversely proportion to an effective area of the first optical fiber, and the second effective non-linearity is directly proportional to a non-linear index of refraction of the second optical fiber and inversely proportion to an effective area of the second optical fiber.

182. The mirror of claim 179, wherein a difference between the first and second effective non-linearities is greater than 20% of at least one of the first and second effective non-linearities.

20 183. The mirror of claim 179, wherein the first and second optical fibers have different dispersions.

25 184. The mirror of claim 179, wherein the coupler splits a power of an optical signal with a first portion traveling in a first direction in the fiber loop and a second portion traveling in a counter-propagating direction in the fiber loop.

185. The mirror of claim 179, wherein at least a portion of one of the first and second optical fibers is a dispersion compensating fiber that has an

absolute magnitude of dispersion of at least 20 ps/nm-km for at least a portion of wavelengths in the signal.

186. The mirror of claim 179, wherein at least a portion of one of the first and second optical fibers is a dispersion compensating fiber that has an absolute magnitude of dispersion of at least 50 ps/nm-km for at least a portion of wavelengths in the signal.

187. The mirror of claim 185, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $2 \text{ W}^{-1}\text{km}^{-1}$.

188. The mirror of claim 185, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $3 \text{ W}^{-1}\text{km}^{-1}$.

189. The mirror of claim 184, wherein the coupler provides substantially equal coupling in the two directions.

190. The mirror of claim 184, further comprising:
a polarization controller coupled to the fiber loop that aligns polarizations of the optical signals of the two directions when the optical signals recombine in the fiber loop.

191. The mirror of claim 179, further comprising:
a lossy element coupled to the fiber loop.

192. The mirror of claim 191, wherein the lossy member is selected from an add/drop multiplexer, a gain equalizer and a dispersion compensating element.

193. The mirror of claim 179, wherein at least one of the first and second optical fibers has a sufficiently large dispersion to minimize phase shift interactions between adjacent wavelength signals of the optical signals.

194. The mirror of claim 193, wherein the phase shift from cross phase modulation between adjacent wavelengths in the optical signals is no more than $\frac{1}{4}$ of a phase shift from self phase modulation of one of the adjacent wavelengths.

5 195. The mirror of claim 179, wherein the mirror provides simultaneous dispersion compensation and boosting of signal to noise ratio of an optical signal.

196. The mirror of claim 179, wherein at least one of the first and second optical fibers has a length of at least 100 m.

197. The mirror of claim 177, further comprising:
a combiner coupled to the at least first loop mirror; and
at least one output fiber coupled to the combiner.

10 198. An optical system for processing optical signals, comprising:
an input optical fiber;
a splitter coupled to the input optical fiber and separates
adjacent channels of an input optical signal; and
at least a first loop mirror coupled to the splitter, the at least first loop
15 mirror including:
a first optical fiber with a first effective non-linearity;
a second optical fiber coupled to the first optical fiber and
forming a fiber loop, the second optical fiber having a second effective non-
linearity that is different from the first effective non-linearity;
20 a bi-directional amplifier coupled to at least one of the first and
second optical fibers; and
a coupler coupled to the first and second optical fibers.

199. The mirror of claim 198, wherein a length of the first optical
fiber is greater than a walk-off length for at least a portion of adjacent
25 wavelengths propagating in the first fiber.

200. The mirror of claim 198, wherein a length of the second fiber is greater than a walk-off length for at least a portion of adjacent wavelengths propagating in the second fiber.

201. The mirror of claim 198, wherein the first effective non-linearity is directly proportional to a non-linear index of refraction of the first optical fiber and inversely proportion to an effective area of the first optical fiber, and the second effective non-linearity is directly proportional to a non-linear index of refraction of the second optical fiber and inversely proportion to an effective area of the second optical fiber.

202. The mirror of claim 198, wherein a difference between the first and second effective non-linearities is greater than 20% of at least one of the first and second effective non-linearities.

203. The mirror of claim 198, wherein the first and second optical fibers have different dispersions.

204. The mirror of claim 198, wherein the coupler splits a power of an optical signal with a first portion traveling in a first direction in the fiber loop and a second portion traveling in a counter-propagating direction in the fiber loop.

205. The mirror of claim 198, wherein at least a portion of one of the first and second optical fibers is a dispersion compensating fiber that has an absolute magnitude of dispersion of at least 20 ps/nm-km for at least a portion of wavelengths in the signal.

206. The mirror of claim 198, wherein at least a portion of one of the first and second optical fibers is a dispersion compensating fiber that has an absolute magnitude of dispersion of at least 50 ps/nm-km for at least a portion of wavelengths in the signal.

207. The mirror of claim 205, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $2 \text{ W}^{-1}\text{km}^{-1}$.

208. The mirror of claim 205, wherein the dispersion compensating fiber has a nonlinear coefficient greater than $3 \text{ W}^{-1}\text{km}^{-1}$.

5 209. The mirror of claim 204, wherein the coupler provides substantially equal coupling in the two directions.

210. The mirror of claim 204, further comprising:
a polarization controller coupled to the fiber loop that aligns
polarizations of the optical signals of the two directions when the optical
10 signals recombine in the fiber loop.

211. The mirror of claim 198, further comprising:
a lossy element coupled to the fiber loop.

212. The mirror of claim 211, wherein the lossy member is selected from
an add/drop multiplexer, a gain equalizer and a dispersion compensating
15 element.

213. The mirror of claim 198, wherein the bi-directional amplifier is coupled to each of the first and second optical fibers.

214. The mirror of claim 198, wherein the bi-directional amplifier is positionally substantially at a midpoint of the fiber loop.

20 215. The mirror of claim 198, wherein the bi-directional amplifier is a rare earth doped amplifier.

216. The mirror of claim 198, wherein the bi-directional amplifier is an erbium- doped fiber amplifier.

25 217. The mirror of claim 198, wherein the bi-directional amplifier is a Raman amplifier.

218. The mirror of claim 198, wherein at least one of the first and second optical fibers has a sufficiently large dispersion to minimize phase shift interactions between adjacent wavelength signals of the optical signals.

219. The mirror of claim 218, wherein the phase shift from cross phase modulation between adjacent wavelengths in the optical signals is no more than $\frac{1}{4}$ of a phase shift from self phase modulation of one of the adjacent wavelengths.

220. The mirror of claim 198, wherein the mirror provides simultaneous amplification and dispersion compensation of an optical signal.

221. The mirror of claim 198, wherein the mirror provides simultaneous amplification, dispersion compensation and boosting of signal to noise ratio of an optical signal.

222. The mirror of claim 198, wherein the bi-directional amplifier provides a gain to the optical signals of at least 10 dB.

223. The mirror of claim 198, wherein at least one of the first and second optical fibers has a length of at least 100 m.

224. The mirror of claim 198, further comprising:
a combiner coupled to the at least first loop mirror; and
at least one output fiber coupled to the combiner.